InSight

Geophysical Mission to Mars

W. Bruce Banerdt

4 October, 2012

InSight Science Team

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InSight

InSight Partner Organizations

JPL
Jet Propulsion Laboratory
California Institute of Technology

NASA ARC

NASA LaRC

LOCKHEED MARTIN

IPGP
INSTITUT DE PHYSIQUE DU GLOBE DE PARIS

isae
Institut Supérieur de l'Aéronautique et de l'Espace

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal institute of Technology Zurich

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

MPS

University of Oxford

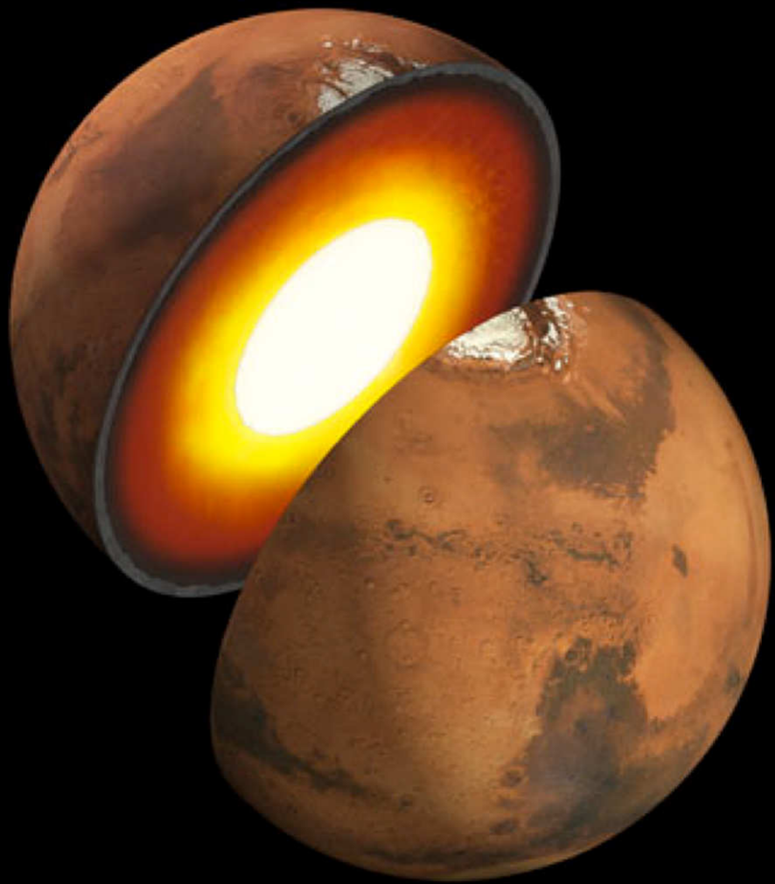
DLR

Imperial College London

UK SPACE AGENCY

InSight Science Goal

To understand the formation and evolution of terrestrial planets through investigation of the interior structure and processes of Mars.

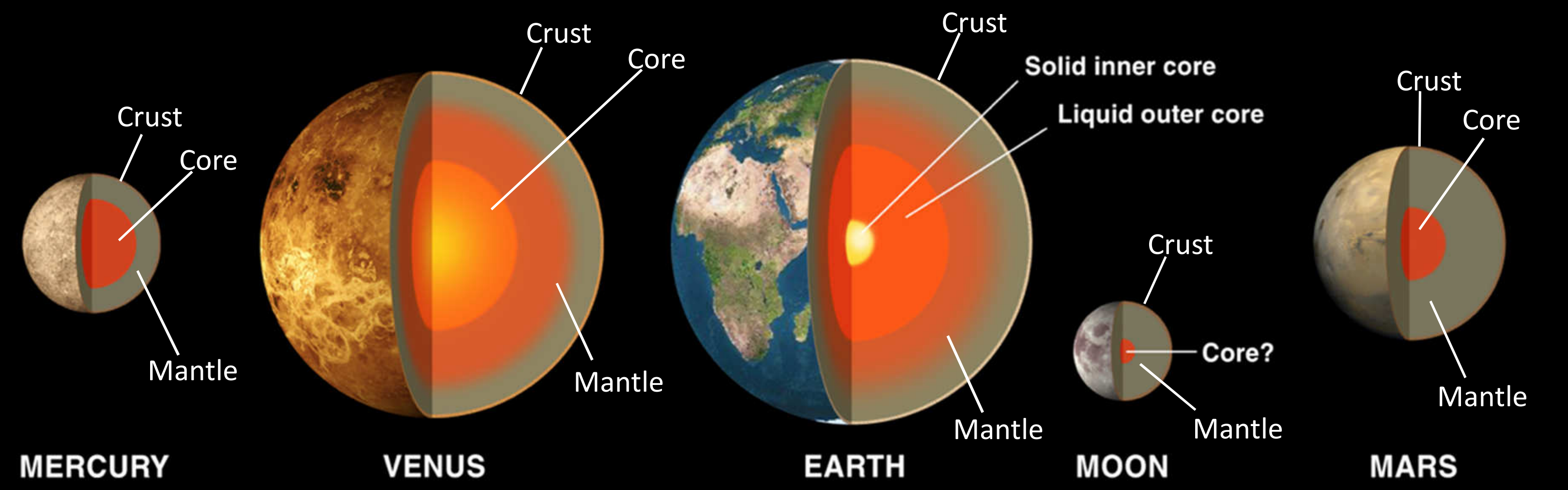


Directly addresses the 2011 Decadal Survey objective to “understand the origin and diversity of terrestrial planets”.

InSight is a terrestrial planets explorer that just happens to be going to Mars…

Mars is Key to Understanding Early Formation of Terrestrial Planets, Including Rocky Exoplanets

Terrestrial planets all share a common structural framework …



But Mars is uniquely well-suited to study the common processes that early-on shaped all rocky planets and govern their basic habitability.

- There is evidence that its basic crust and mantle structure have survived little changed from the first few hundred Myr of formation.
- Its surface is much more accessible than Mercury, Venus.
- Our knowledge of its geology, chemistry, climate history provides a rich scientific context for using interior information to increase our understanding of the solar system.

What's So Special About Mars?

- Because of vigorous mantle convection and plate tectonics, the Earth has lost virtually all structural evidence reflecting its differentiation and early evolution.
- Mars likely retains such evidence in its lateral and radial compositional variations.
  - SNC isotopic analyses indicate that isolated melt source regions have persisted since early in Mars' history, suggesting that mantle convection has been insufficiently vigorous to homogenize the mantle.
  - Noble gas measurements indicate that only ~3% of Ar produced from ^{40}K has been degassed from Mars' mantle, compared to >50% for the Earth.
  - Much of the martian crust dates to the first half billion years of solar system history (or earlier).
- Therefore, investigations of the martian interior are likely to find structures that still reflect differentiation and early planetary formation processes.

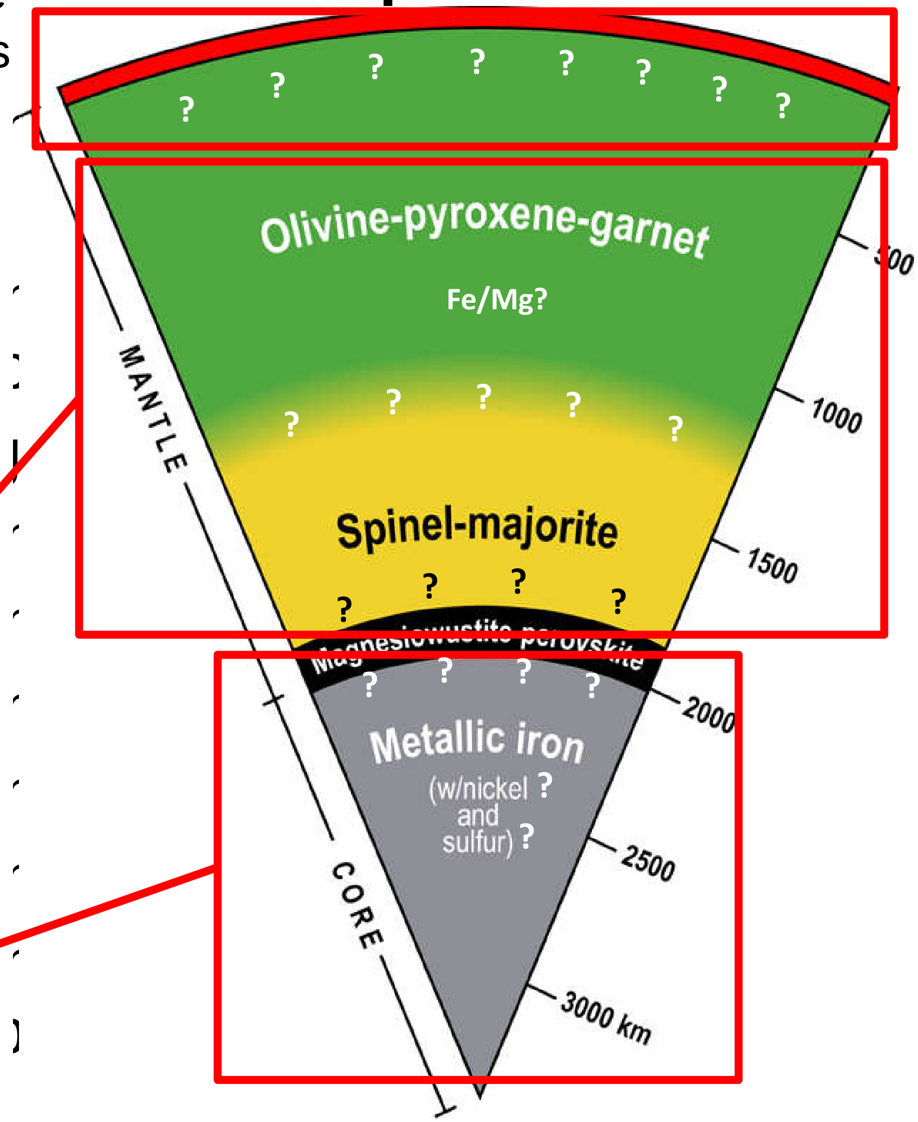
Direct Linkage Between Science Objectives and Requirements
Internal Structure Provides a Window into the Planet's Past

Level 1 Requirements

- **Crust:** Its **thickness** and vertical structure (**layering** of different compositions) reflects the depth and crystallization processes of the magma ocean and the early post-differentiation evolution of the planet (plate tectonics vs. crustal overturn vs. immobile crust vs. …).

- **Mantle:** Its behavior (e.g., convection, partial melt generation) determines the manifestation of the thermal history on a planet's surface; depends directly on its **thermal structure** and **stratification**.

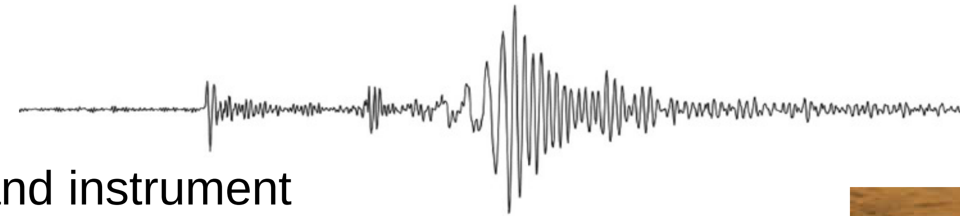
- **Core:** Its **size** and composition (**density**) reflect conditions of accretion and early differentiation; its **state** (liquid vs. solid) reflects its composition and the thermal history of the planet.



Focused Set of Measurements

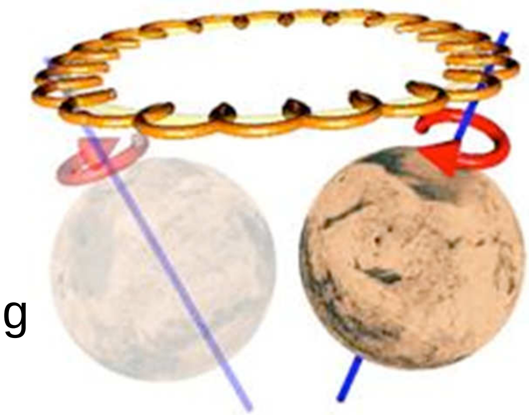
- InSight capitalizes on advances in technology and analysis to enable results that previously required 4 stations and >$1B.

  – **Single-Station Seismology**



  - Extremely sensitive, broad-band instrument
  - Surface installation and effective environmental isolation
  - Single-station seismic analysis techniques
  - Multiple signal sources

  – **Precision Tracking**



  - Sub-decimeter (~2 cm) X-band tracking

  – **Heat Flow**

  - Innovative, self-penetrating mole penetrates to a depth of 3–5 meters

Science Payload

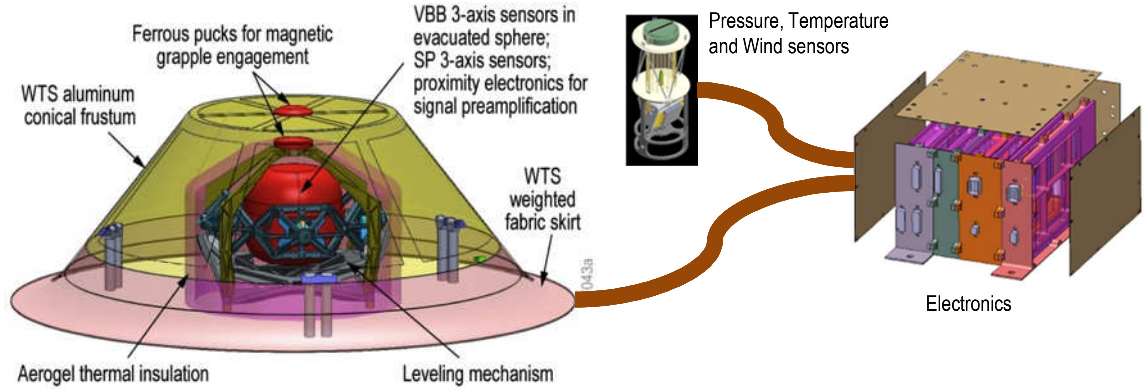
Small Deep Space Transponder

RISE (S/C Telecom)

Rotation and Interior Structure Experiment

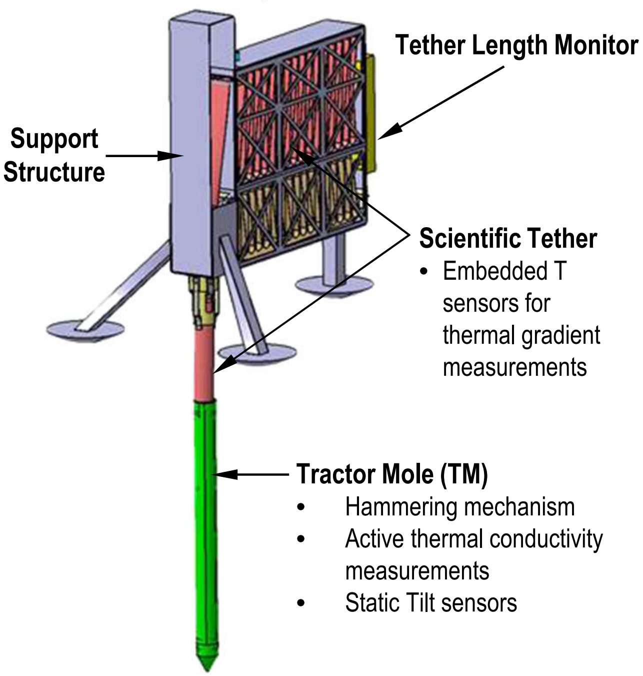
SEIS (CNES) (also ETH/ESA, MPS/DLR, IC/Oxford/UKSA, JPL)

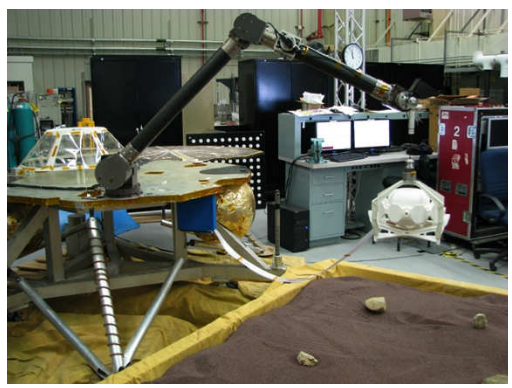
Seismic Experiment for Interior Structure



HP³ (DLR)

Heat Flow and Physical Properties Probe





Surface Deployment Test Bed

IDA (JPL) – Instrument Deployment Arm)

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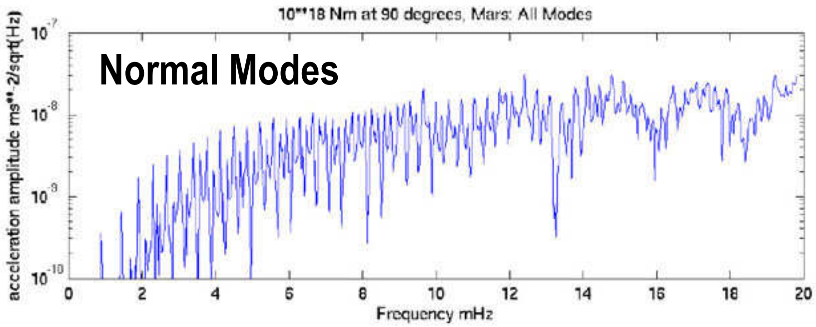
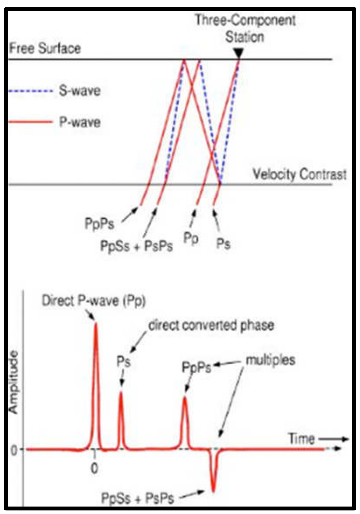
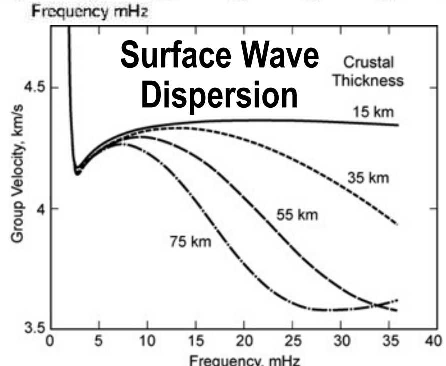
Martian Seismology – SEIS

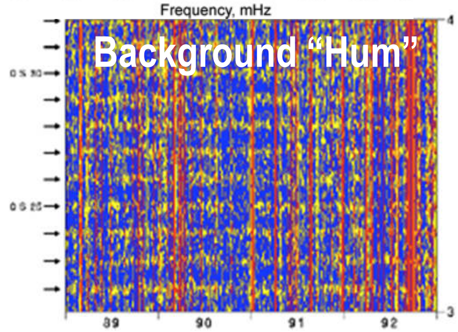
Multiple Analysis Techniques

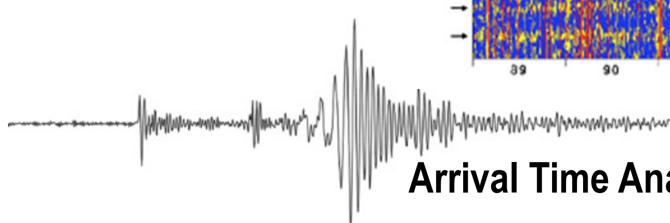




Receiver Function

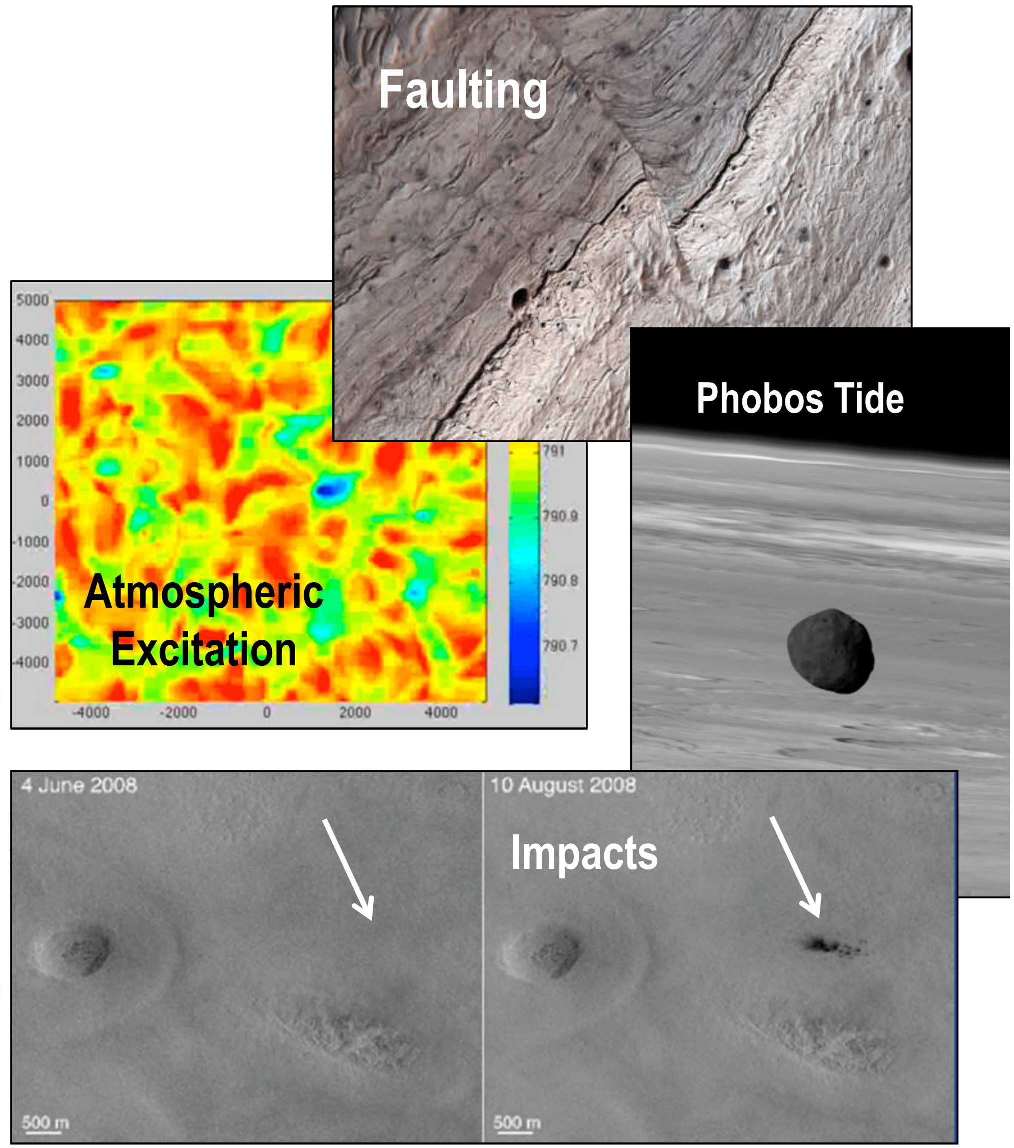






Arrival Time Analysis

Multiple Signal Sources



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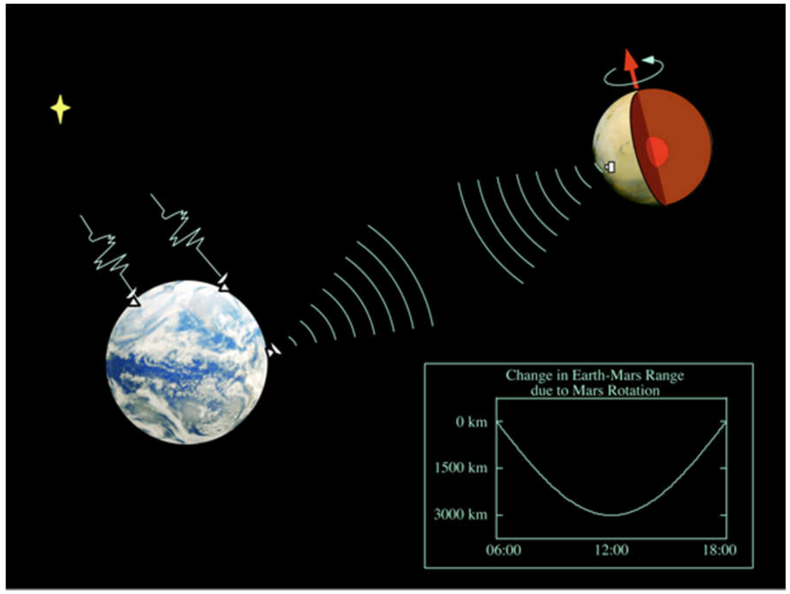
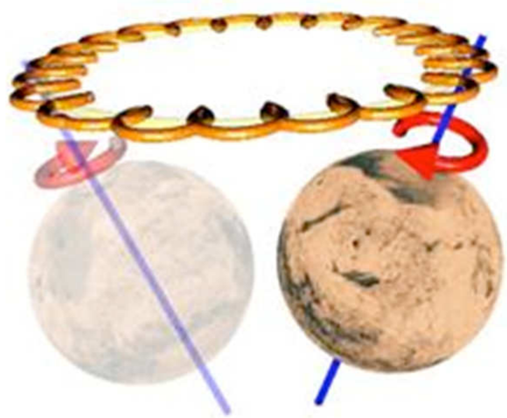
  - Free core nutation constrains core MOI directly, allowing separation of radius and density.



precession/nutation



Heat Flow Measurement – HP³

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  - It trails a tether containing precise temperature sensors every ~30 cm to measure the temperature profile of the subsurface.
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- Together, these yield the rate of heat flowing from the interior.
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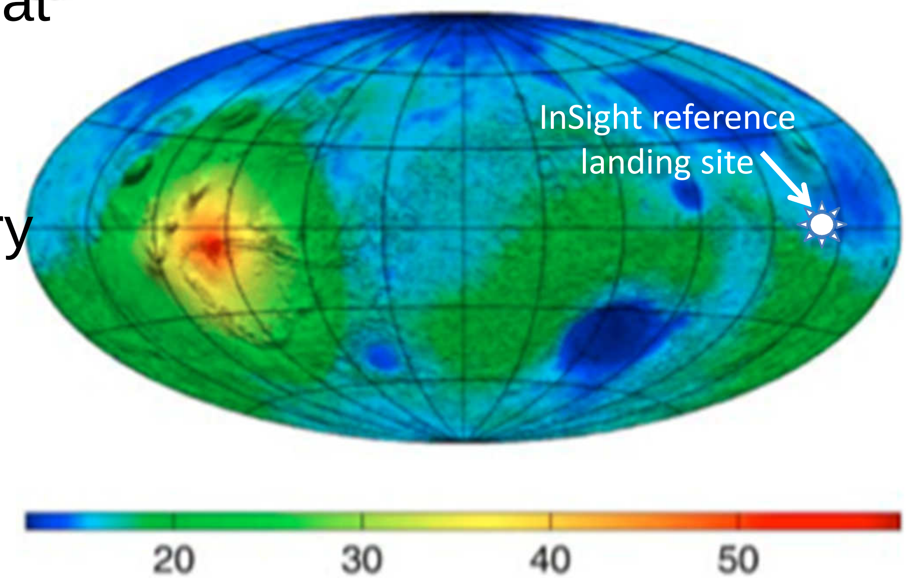
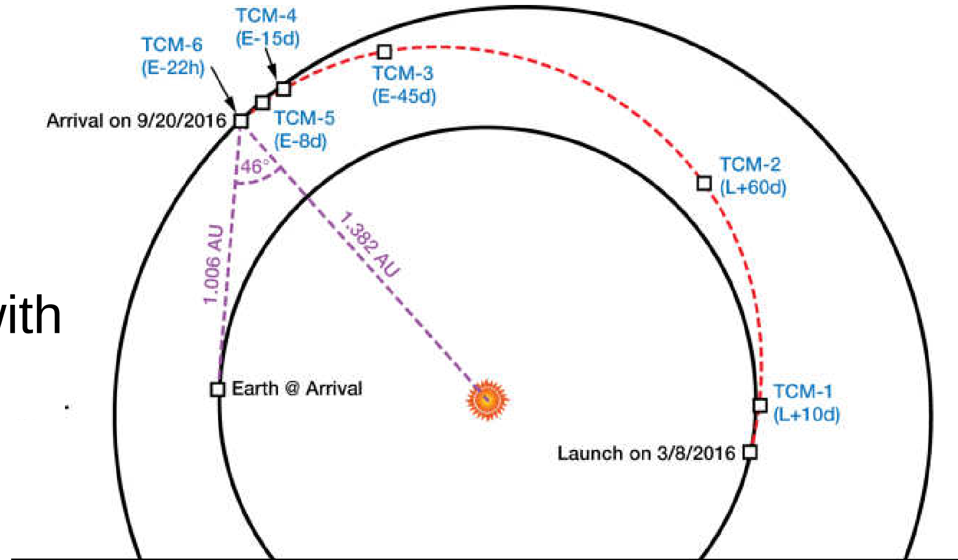
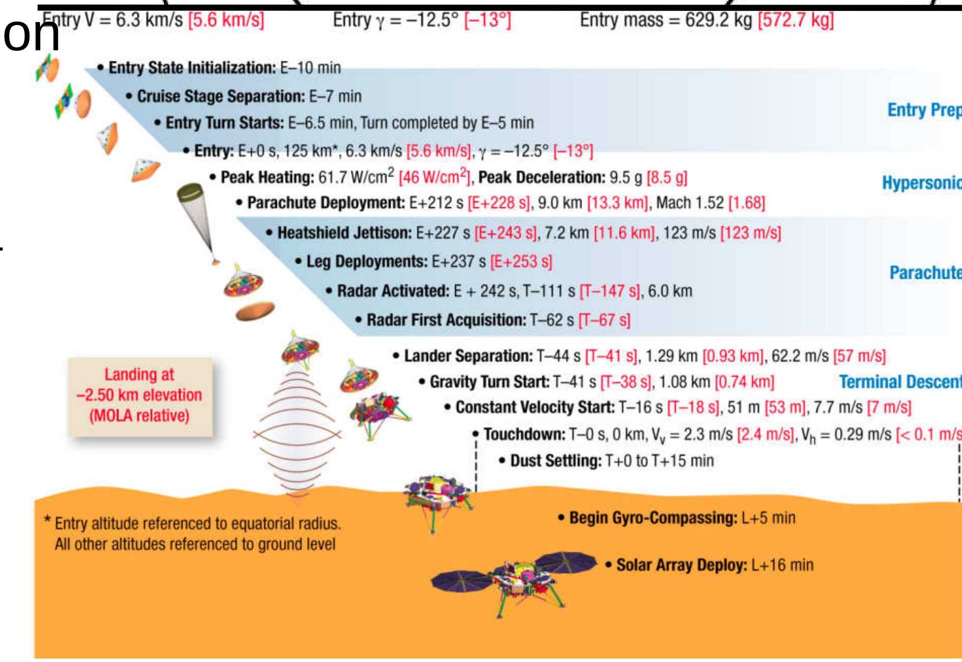


Surface Heat Flow Model (mW/m²)

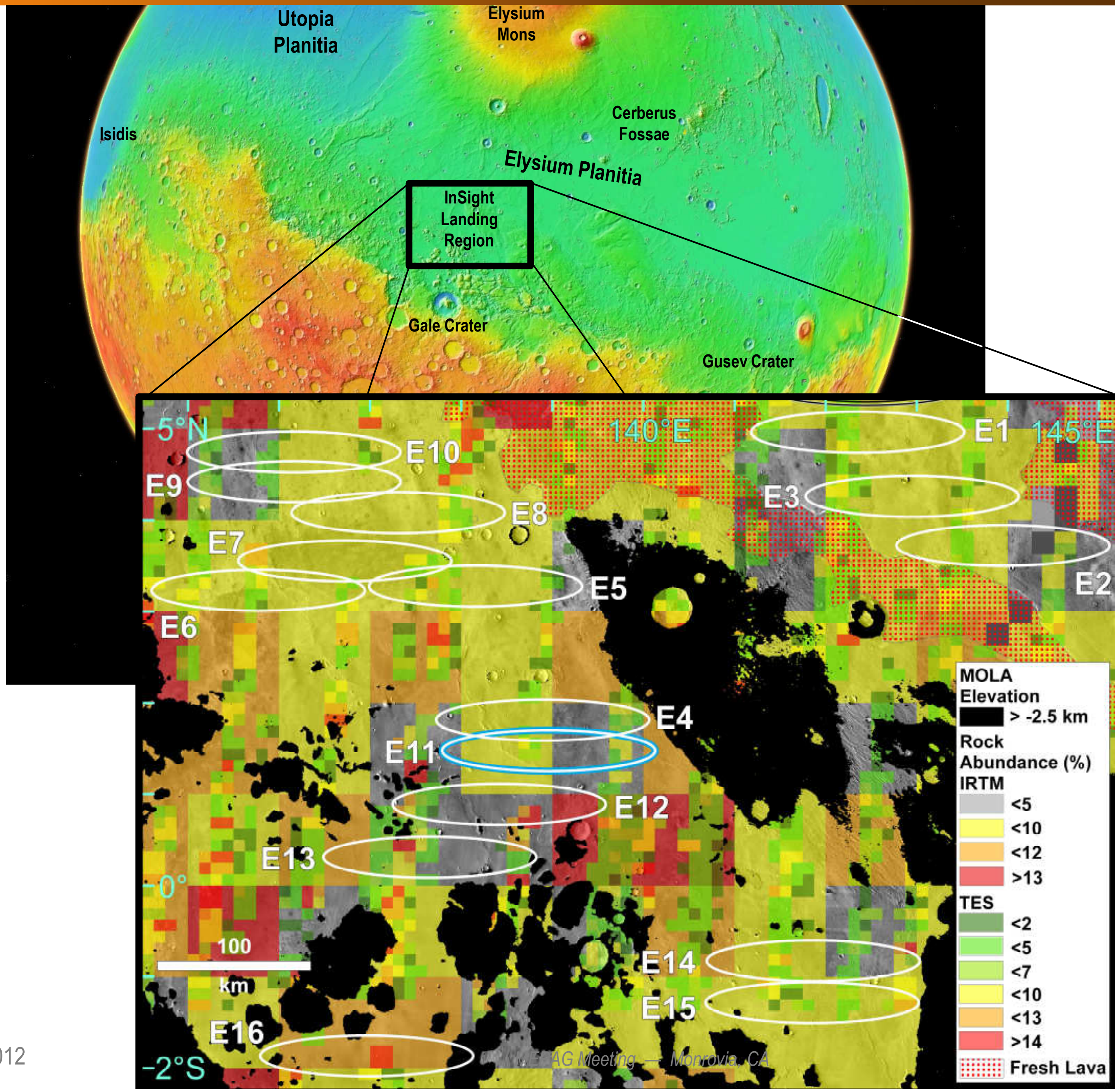
Mission Overview

- 20-day launch period opens on 8 March 2016
  - Constant Arrival Date of 20-Sep-2016
- Type 1 transfer from Earth-to-Mars with 6.5-month Cruise Phase
- Direct entry, deceleration using heat shield and parachute, final descent on thrusters
- Landing in western Elysium Planitia
- Surface deployment of instruments during first 60 sols.
- Full Mars year of surface science operations



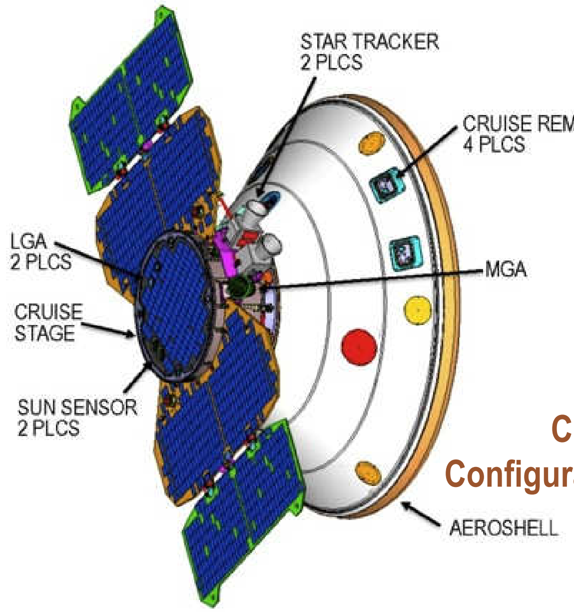


InSight Landing Region – Western Elysium Planitia

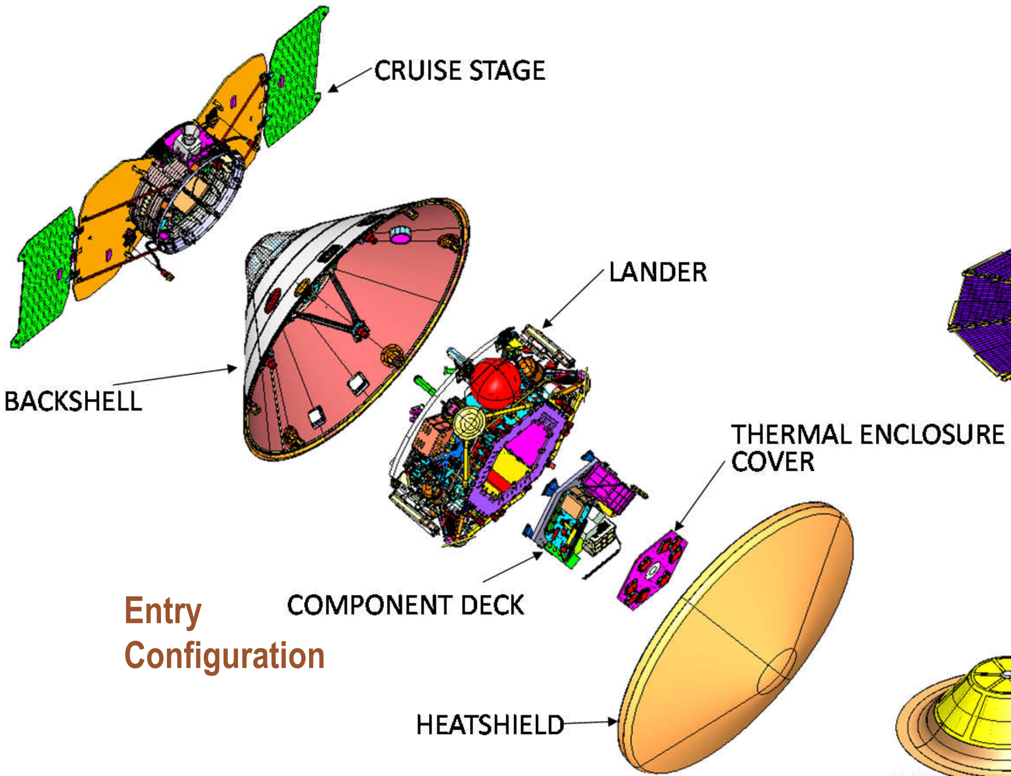


Spacecraft

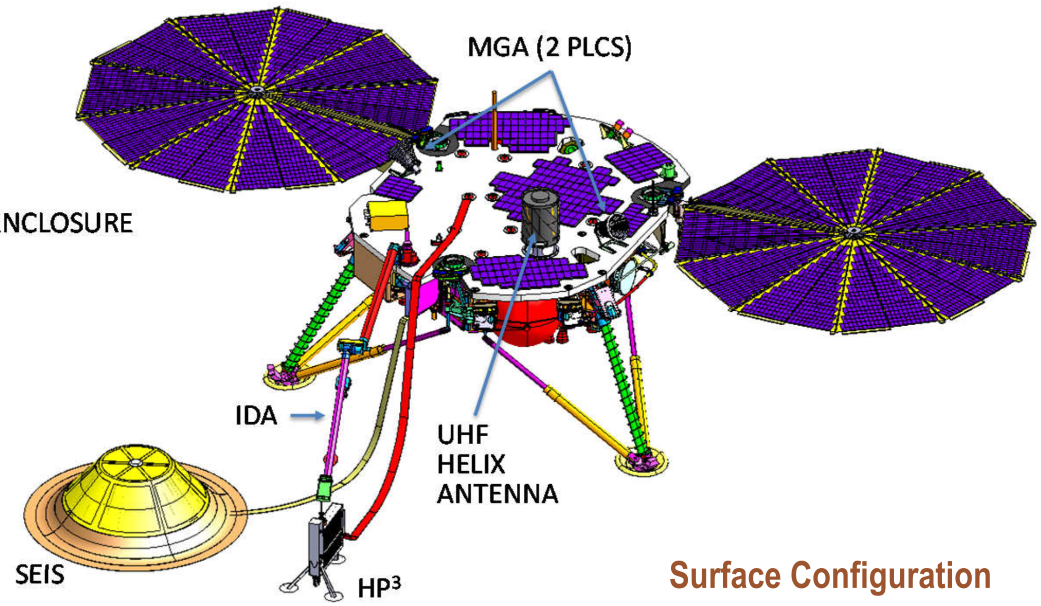
- InSight will fly a near-copy of the successful Phoenix Flight System
  - System (including hardware, procedures, and personnel) has already operated on Mars
  - Only minor changes required for InSight



Cruise Configuration



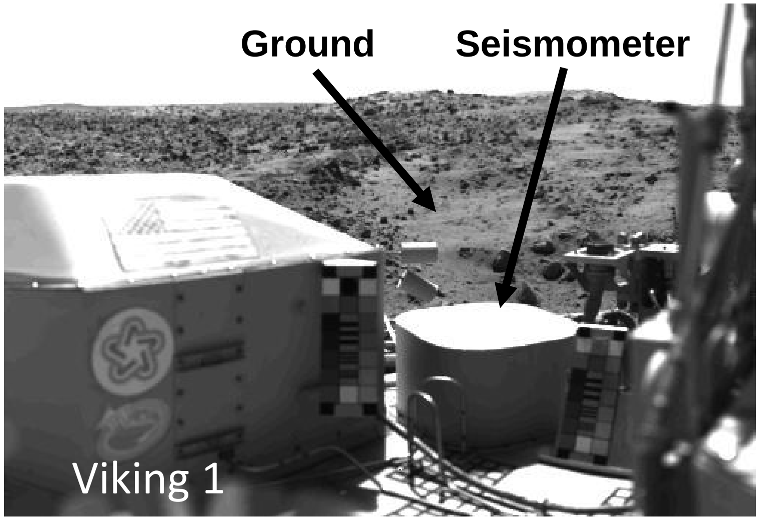
Entry Configuration

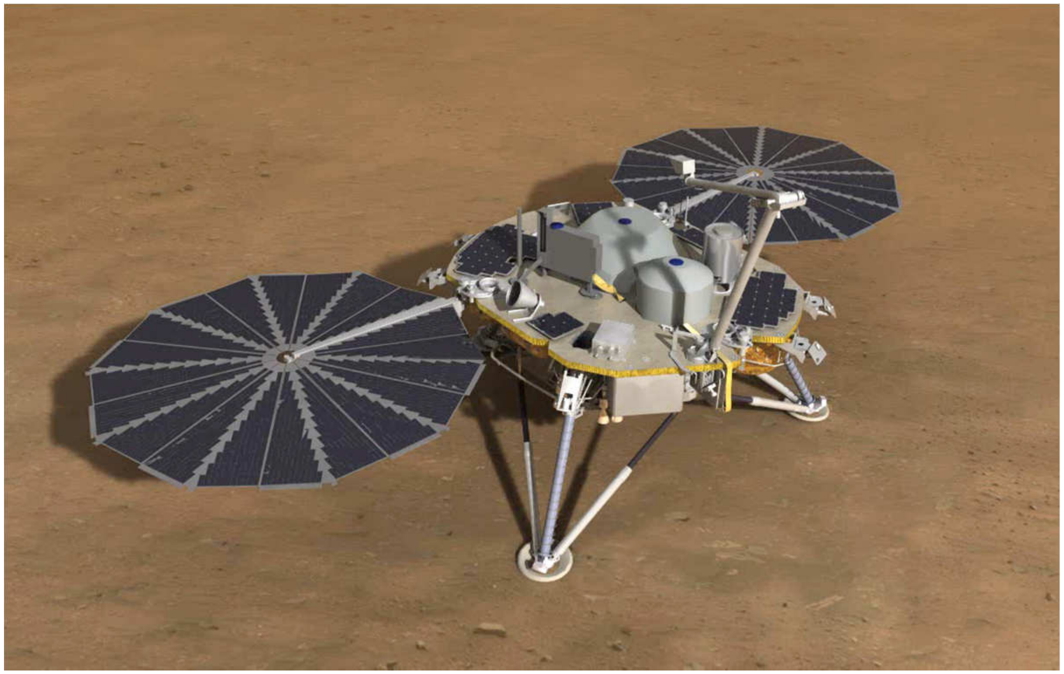


Surface Configuration

Surface Deployment and Operations

- Surface installation is critical for achieving InSight's science.
- After landing the instruments are still ~1 m from the ground
- The 60-sol Surface Deployment Phase completes this process

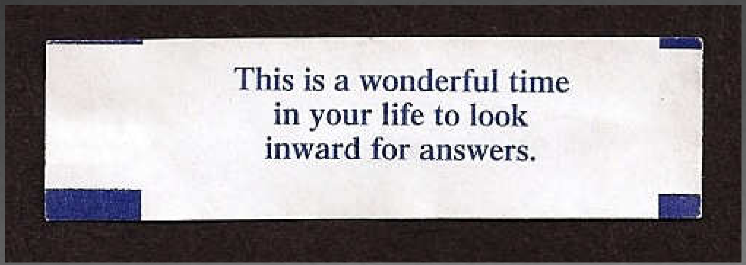


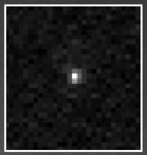


- Seismometer installation achieves direct ground contact and environmental isolation.
- HP^3 deployment positions the mole for penetration 3-5 meters beneath the surface of Mars.

InSight Timeline

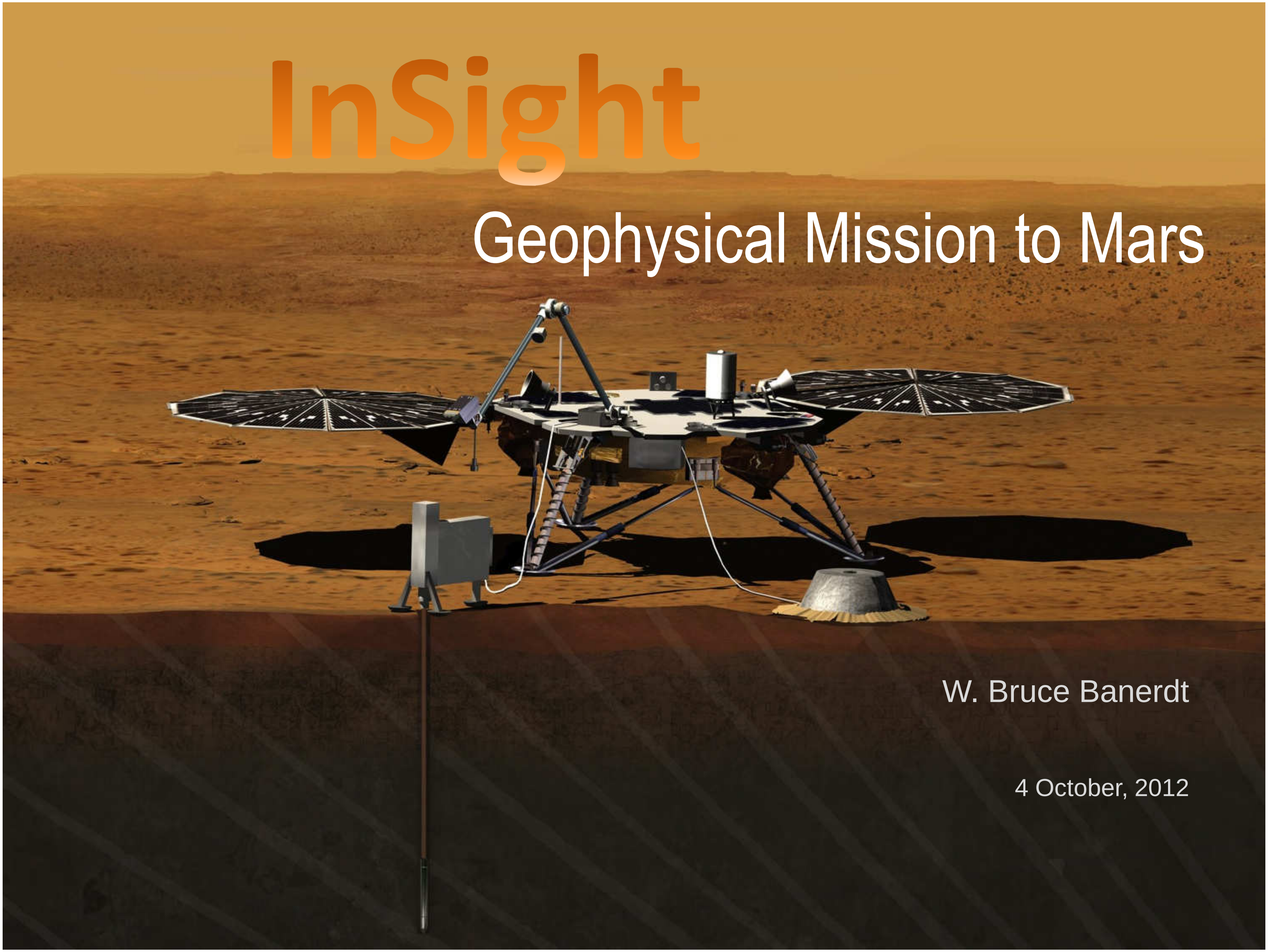
• Aug. 20, 2012	Selection
• Aug. 29, 2012	Begin Phase B
• Aug.13, 2013	PDR
• May 6, 2014	CDR
• Nov. 4, 2014	Start ATLO
• Jan. 9, 2015	Deliver Instruments
• Dec. 7, 2015	Ship to Cape
• Mar. 8-28, 2016	Launch (3 years, 5 months, 4 days!)
• Sept. 20, 2016	Mars Landing
• Sept. 12, 2018	End of Nominal Mission


This is a wonderful time
in your life to look
inward for answers.


Earth, seen from Mars

Look deep into nature, and then you will understand everything better. – Albert Einstein

Gusev Crater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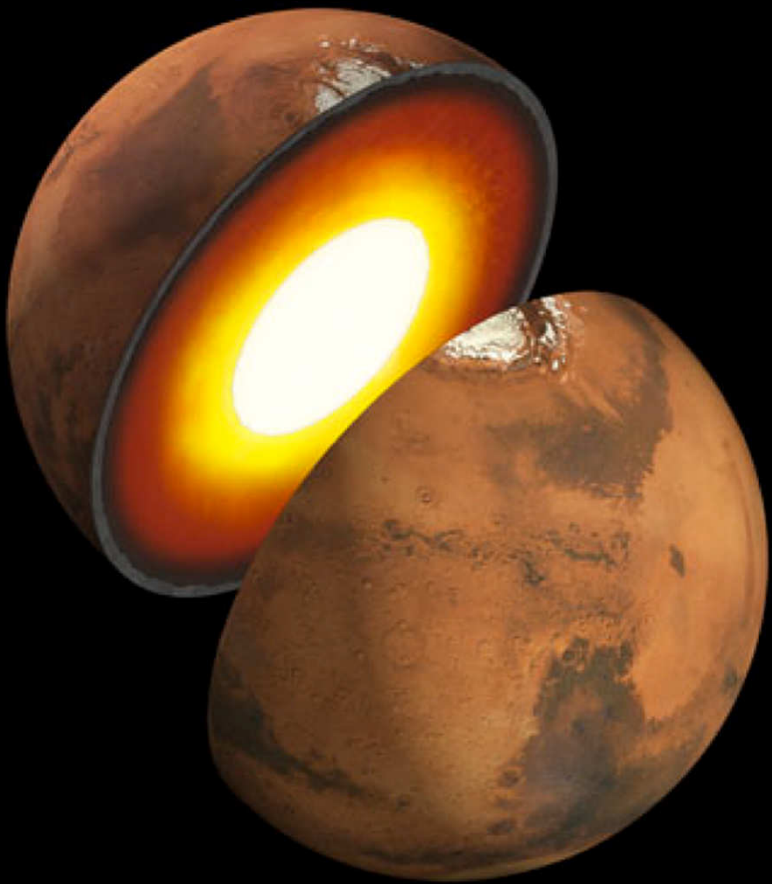

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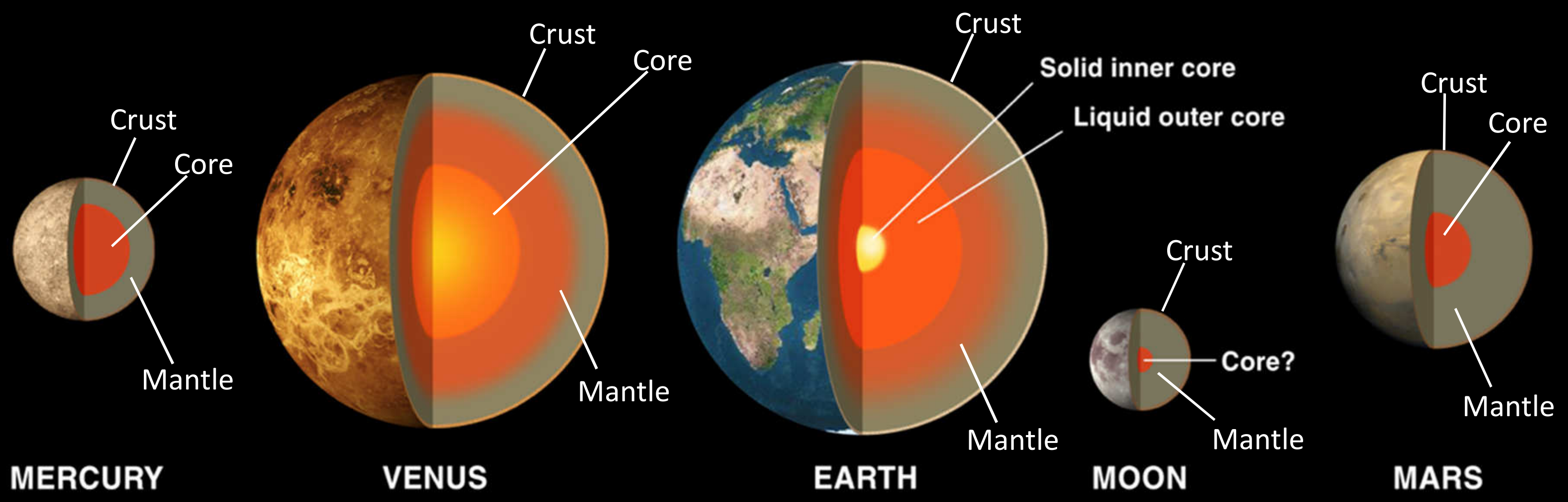

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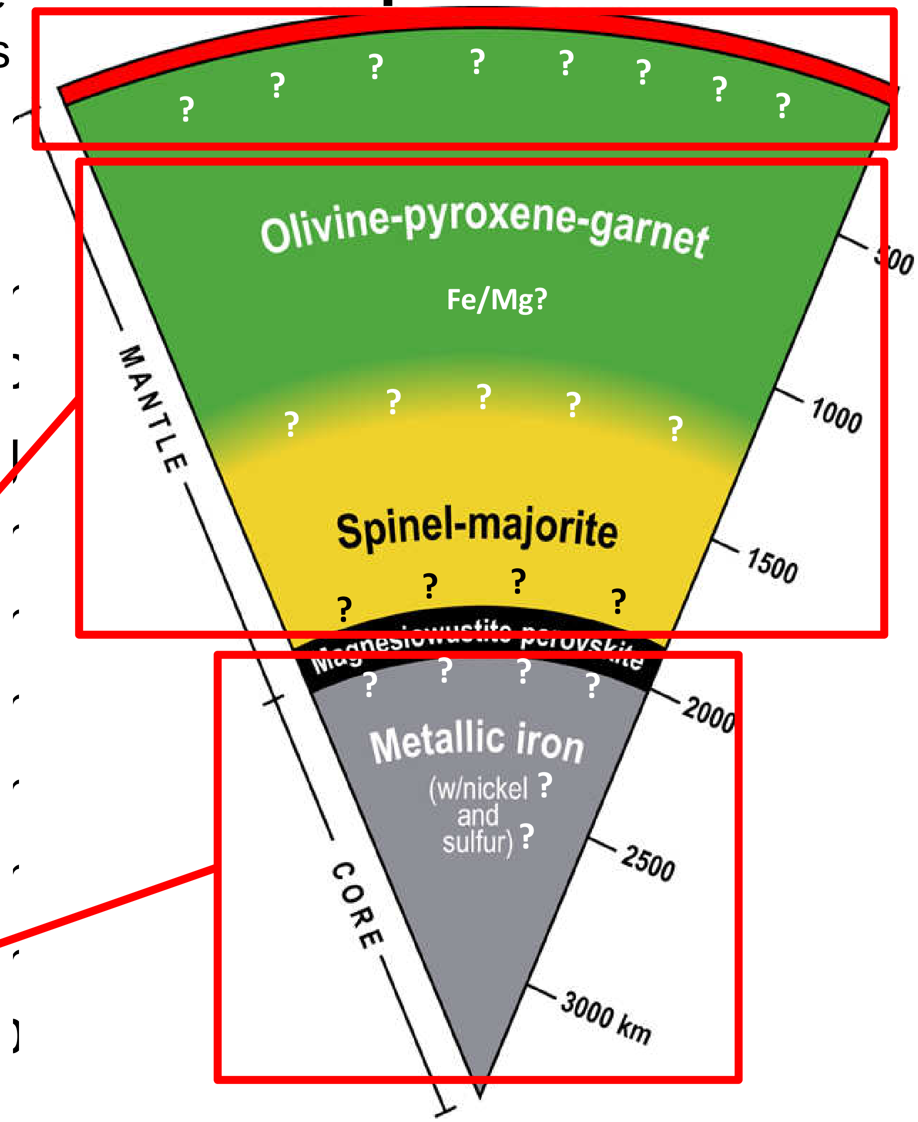
Level 1 Requirements



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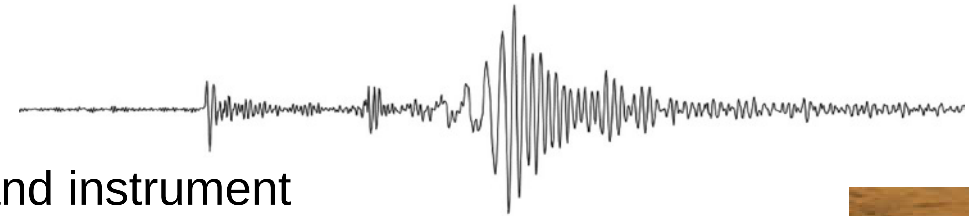

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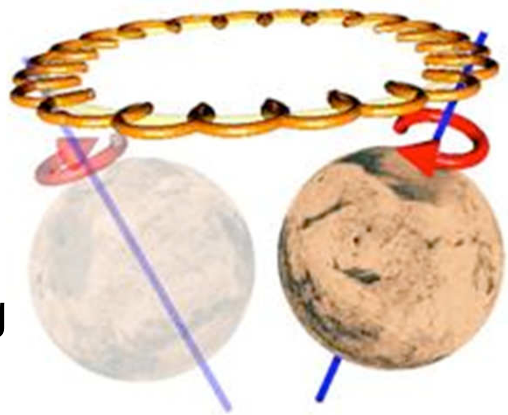

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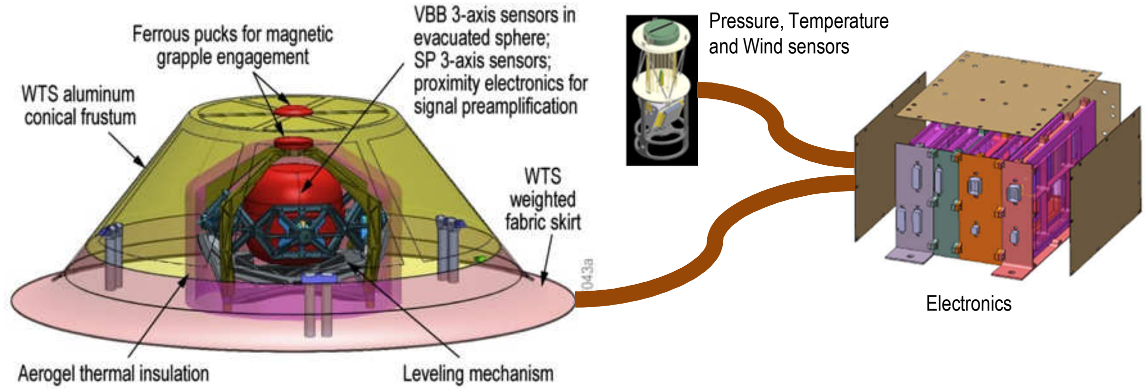

HP^3 (DLR)

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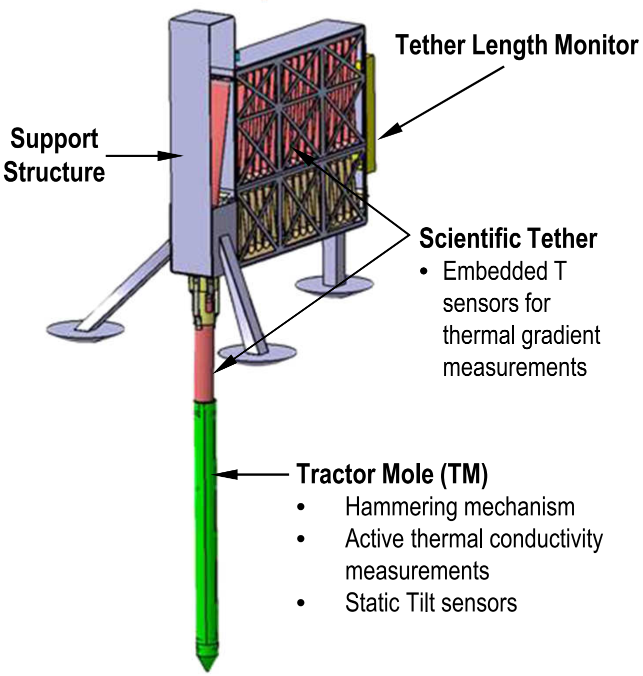

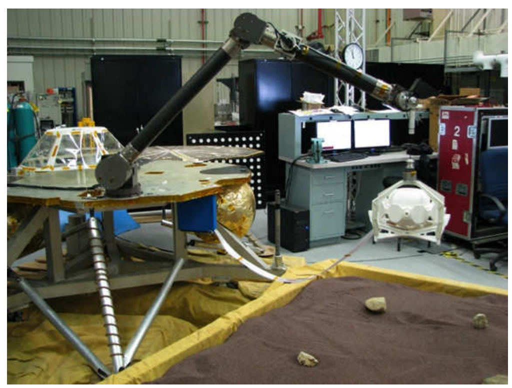

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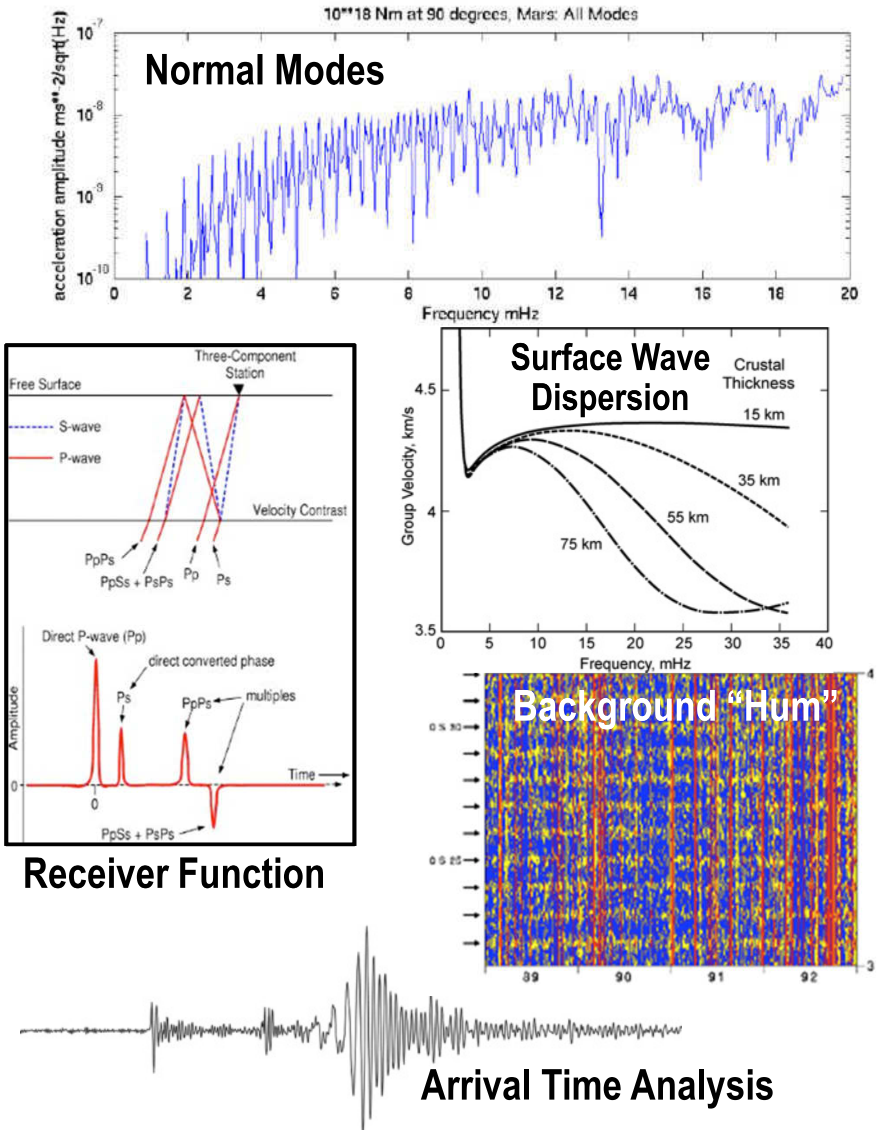

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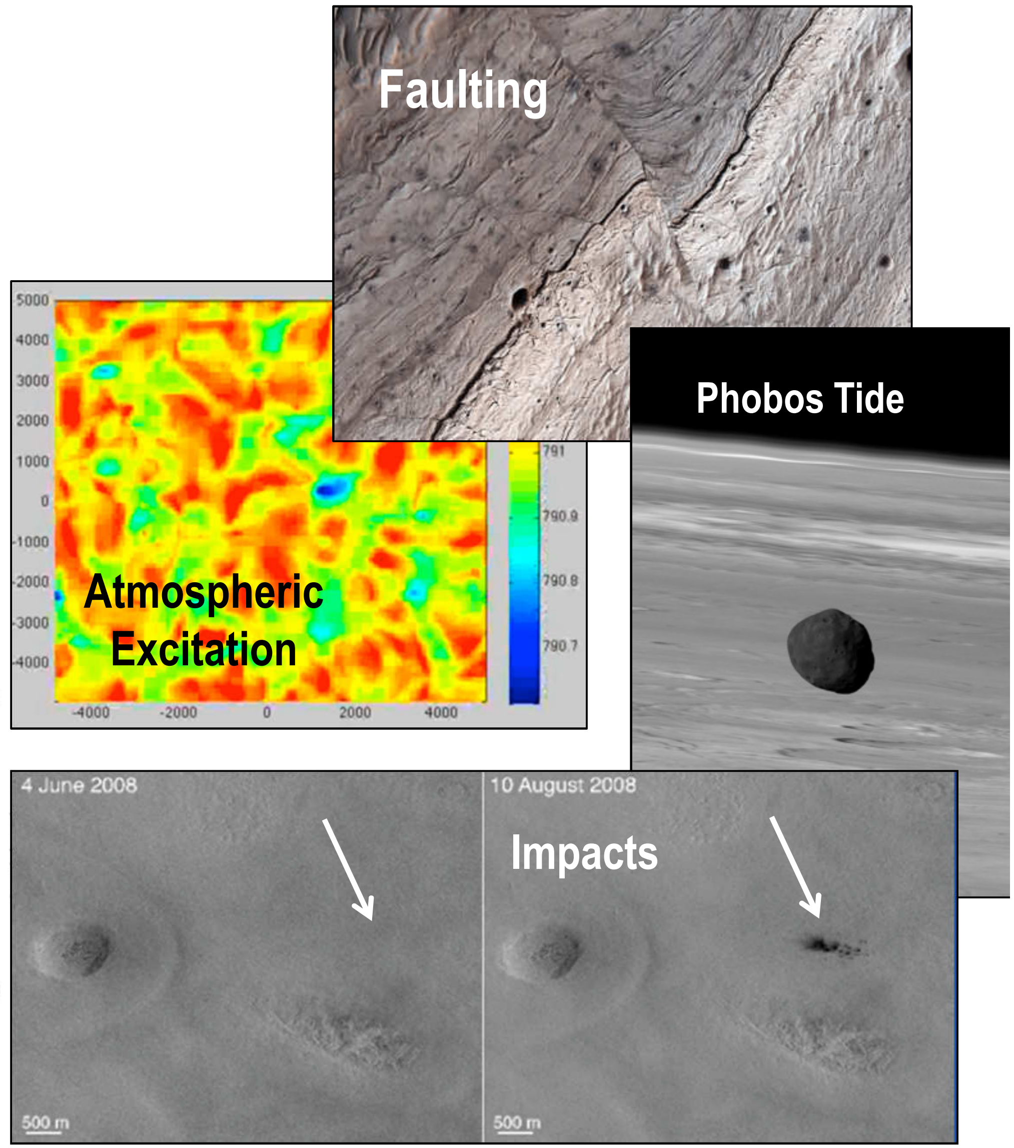

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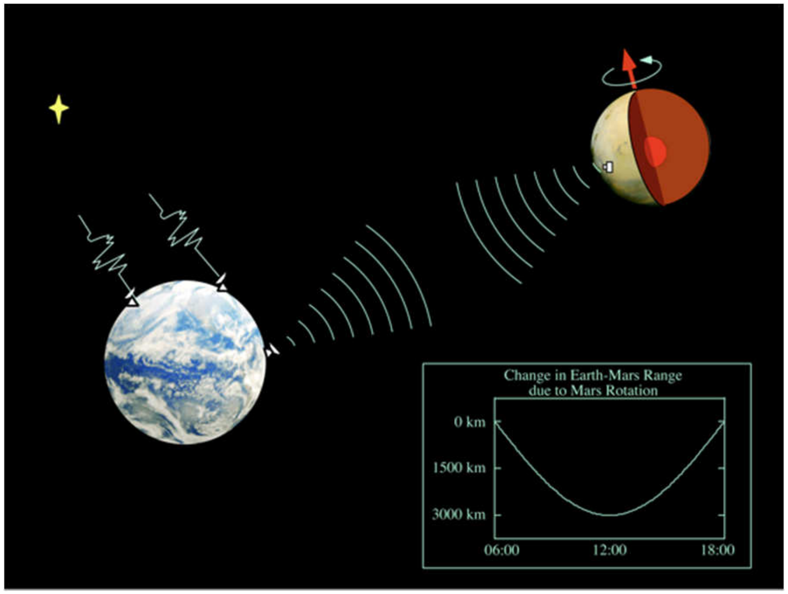

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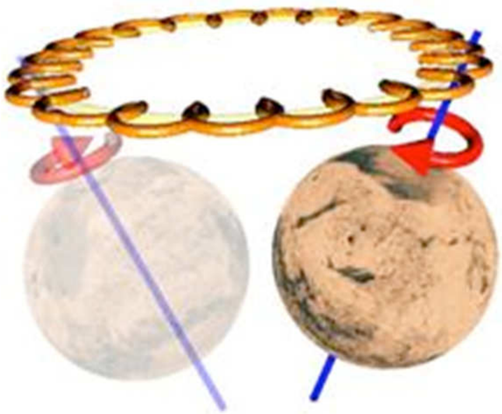

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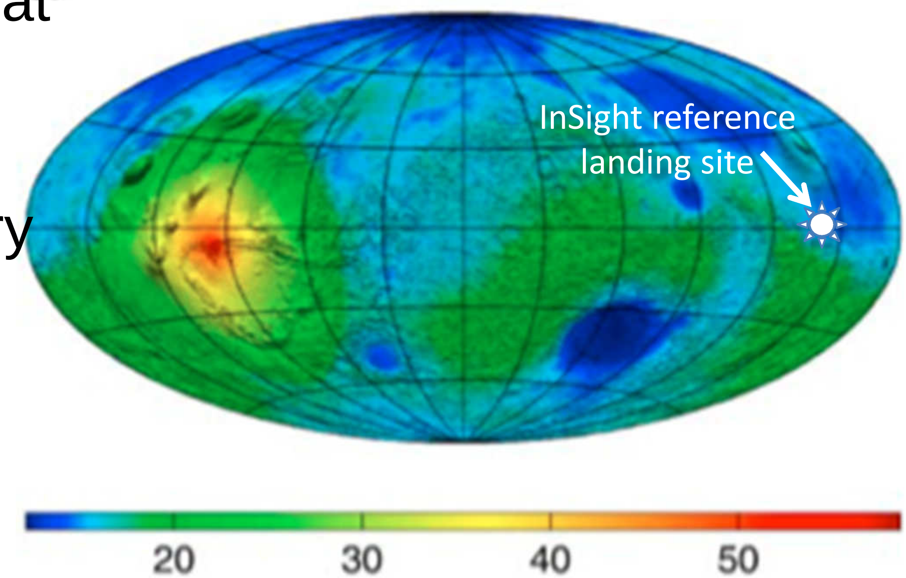

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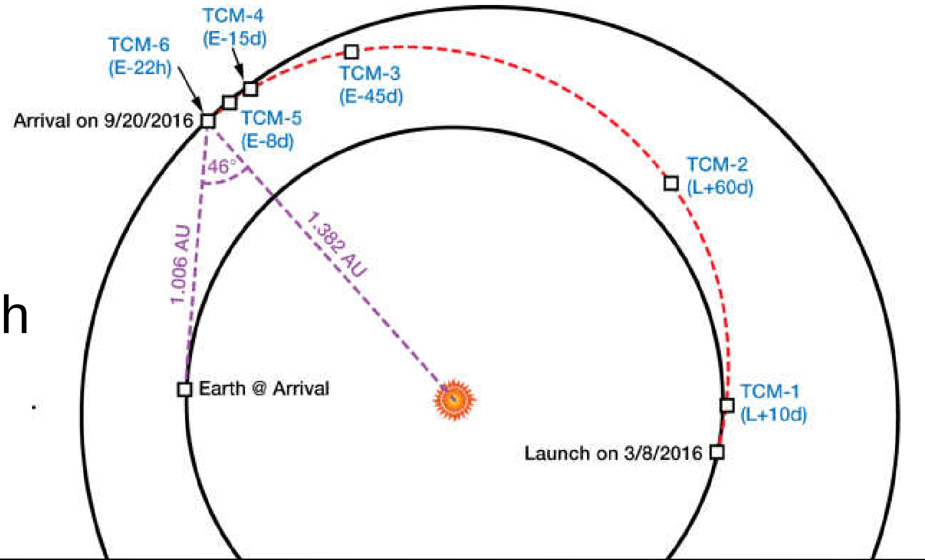
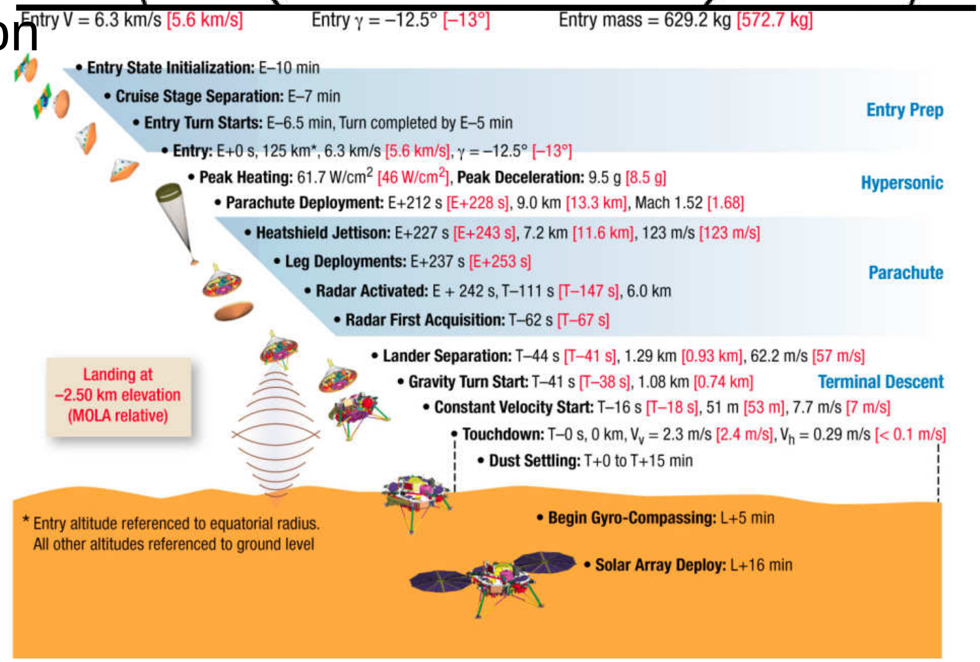
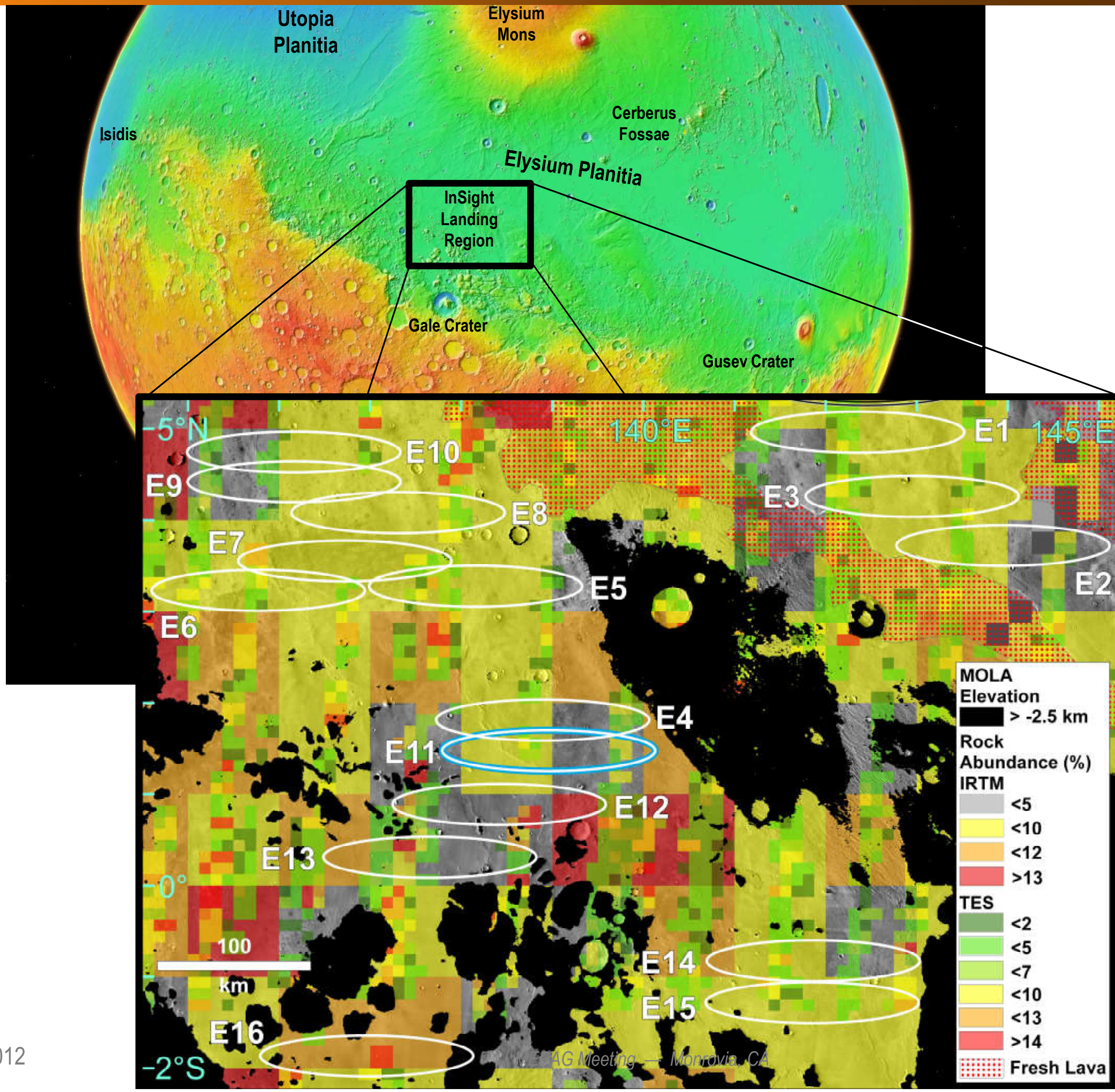
- Surface deployment of instruments during first 60 sols.
- Full Mars year of surface science operations



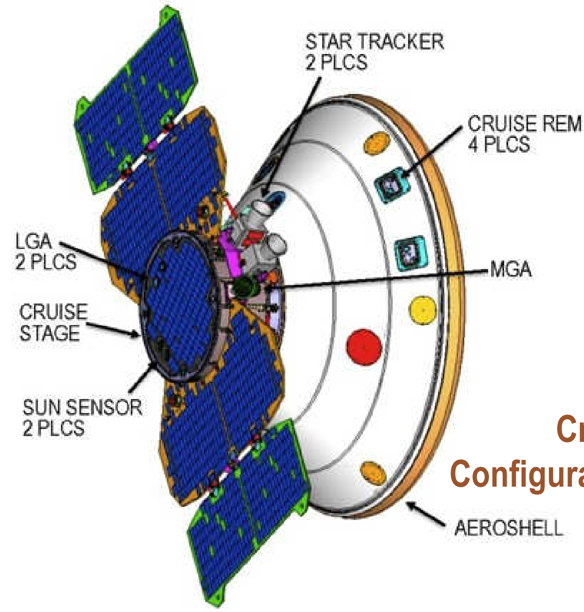


InSight Landing Region – Western Elysium Planitia

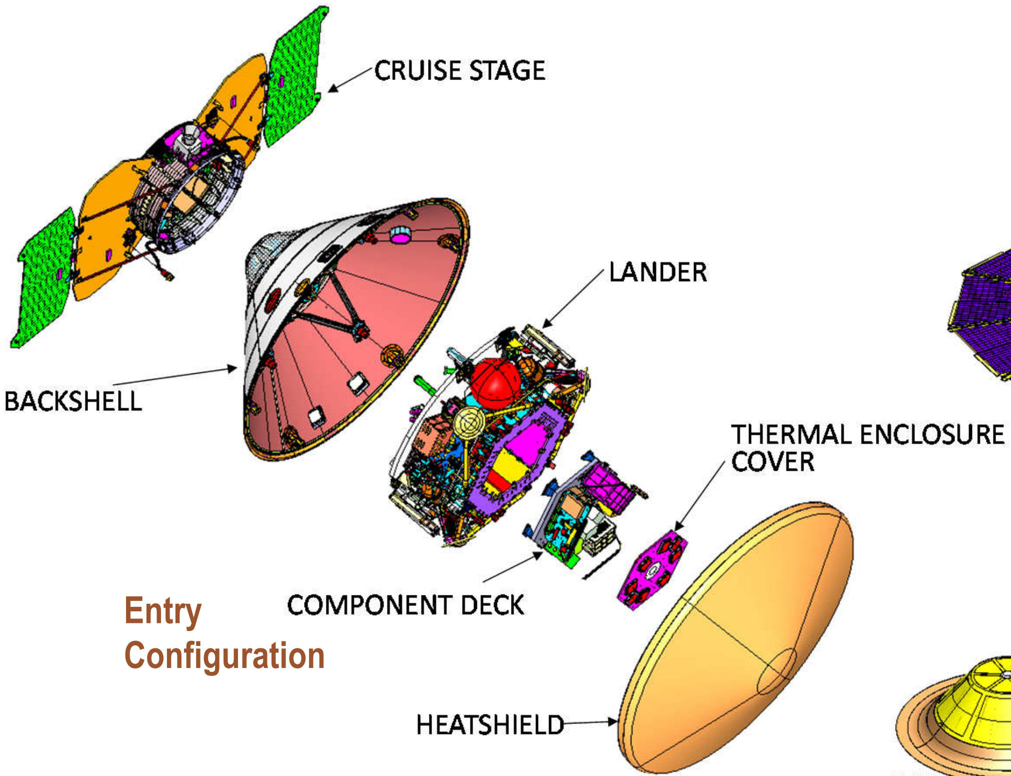


Spacecraft

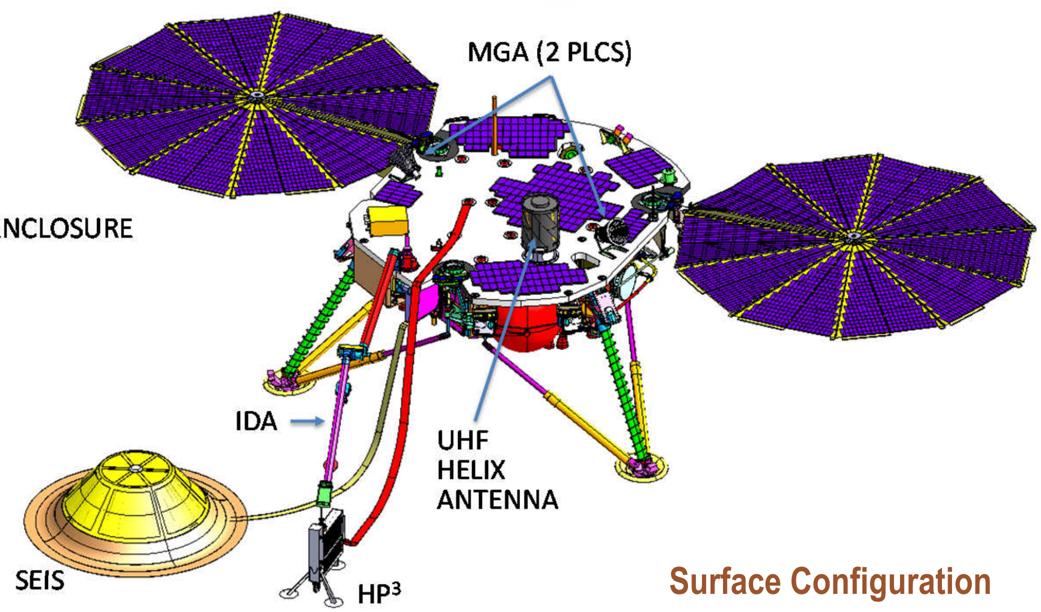
- InSight will fly a near-copy of the successful Phoenix Flight System
  - System (including hardware, procedures, and personnel) has already operated on Mars
  - Only minor changes required for InSight



Cruise Configuration



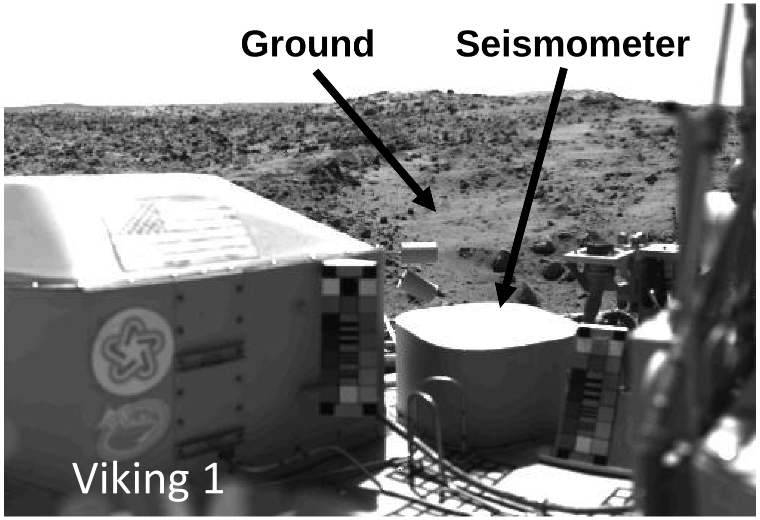
Entry Configuration

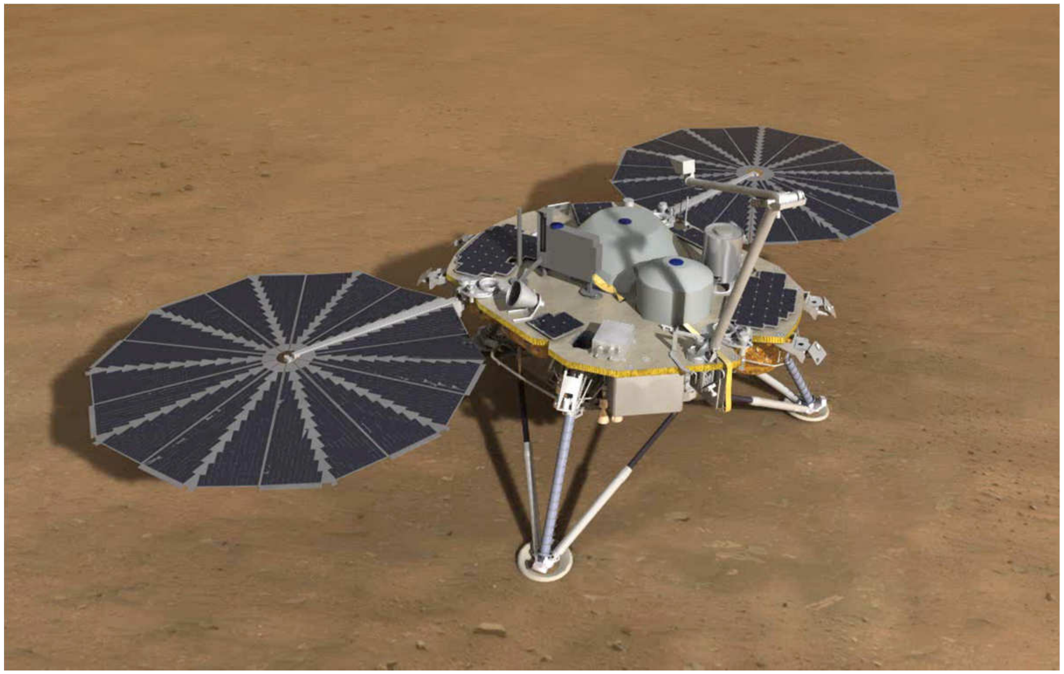


Surface Configuration

Surface Deployment and Operations

- Surface installation is critical for achieving InSight's science.
- After landing the instruments are still ~1 m from the ground
- The 60-sol Surface Deployment Phase completes this process

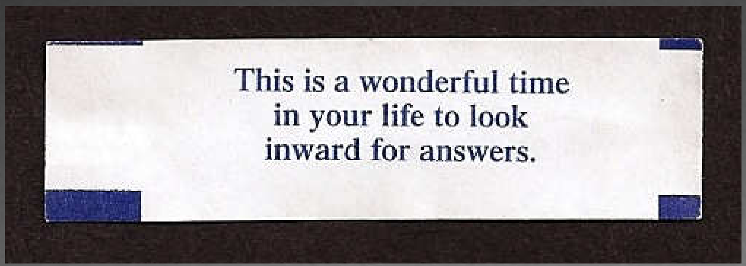


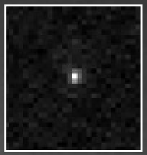


- Seismometer installation achieves direct ground contact and environmental isolation.
- HP^3 deployment positions the mole for penetration 3-5 meters beneath the surface of Mars.

InSight Timeline

• Aug. 20, 2012	Selection
• Aug. 29, 2012	Begin Phase B
• Aug.13, 2013	PDR
• May 6, 2014	CDR
• Nov. 4, 2014	Start ATLO
• Jan. 9, 2015	Deliver Instruments
• Dec. 7, 2015	Ship to Cape
• Mar. 8-28, 2016	Launch (3 years, 5 months, 4 days!)
• Sept. 20, 2016	Mars Landing
• Sept. 12, 2018	End of Nominal Mission


This is a wonderful time
in your life to look
inward for answers.



Earth, seen from Mars

Look deep into nature, and then you will understand everything better. – Albert Einstein

Gusev Crater